

What is claimed is:

- 1 1. A waveguide photodetector system, comprising:
2 a multiple mode interference (MMI) cavity having an input end and an
3 output end;
4 an input waveguide optically coupled to the MMI cavity at the input end;
5 and
6 an array of detector waveguides optically coupled to the MMI cavity at the
7 output end and each optically coupled to an intrinsic region surrounded by first and
8 second electrodes.
- 1 2. The system of claim 1, wherein the input waveguide is single-mode.
- 1 3. The system of claim 2, wherein the MMI cavity produces N interference
2 nodes at the output end, and wherein each detector waveguide is arranged at or near
3 an interference node.
- 1 4. The system of claim 1, wherein the input waveguide, MMI cavity and
2 detector waveguides comprise a material selected from the group of materials
3 comprising: Si, Ge, Ge on Si, $\text{Ge}_x\text{Si}_{1-x}$, SiO_xN_y and Si_3N_4 .
- 1 5. The system of claim 3, wherein the intrinsic region comprises silicon.
- 1 6. The system of claim 3, wherein the intrinsic region comprises germanium.
- 1 7. The system of claim 1, wherein the first and second electrodes associated
2 with each of the intrinsic regions are connected in parallel.

- 1 8. The system of claim 7, further including:
2 an input device optically coupled to the first waveguide to provide an optical
3 signal to be detected; and
4 an output device electrically coupled to the first and second electrodes so as
5 to receive an outputted photocurrent.
- 1 9. The system of claim 8, wherein the input device includes a laser.
- 1 10. The system of claim 1, wherein the first and electrodes are respectively n+
2 doped and p+ doped silicon.
- 1 11. The system of claim 1, wherein the detector waveguides are coupled to the
2 respective intrinsic regions by evanescent coupling.
- 1 12. The system of claim 1, wherein the intrinsic region has a carrier collection
2 distance of less than 1 micron.
- 1 13. The system of claim 1, wherein each detector waveguide has a core with a
2 core width, and wherein each intrinsic region has a carrier collection distance
3 substantially equal to the core width.
- 1 14. The system of claim 1, wherein the detector waveguides are single mode.
- 1 15. The system of claim 1, wherein the system has a detection speed of 10 GHz
2 or greater.
- 1 16. A method of generating an output photocurrent from a guided lightwave,
2 comprising:
3 dispersing the guided lightwave into multiple (N) guided lightwave modes;
4 forming N interference nodes from the N guided lightwave modes;

5 coupling the light from the N interference nodes into corresponding N
6 waveguides;

7 coupling the light traveling in each of the N waveguides to a corresponding
8 intrinsic region in each of N PIN detectors to generate the output photocurrent.

1 17. The method of claim 16, including connecting the N PIN detectors in
2 parallel.

1 18. The method of claim 16, wherein the coupling of light from the waveguides
2 to the intrinsic regions is performed via evanescent coupling.

1 19. The method of claim 18, wherein each waveguide has a core with a width,
2 and including forming the intrinsic region so as to have a width substantially the
3 same as the waveguide core width.

1 20. The method of claim 19, wherein one or more of the waveguides are single
2 mode.

1 21. The method of claim 20, including forming the PIN detector with self-
2 aligned n+ and a p+ electrodes surrounding the intrinsic region.

1 22. The method of claim 21, wherein dispersing the guided lightwave is
2 performed using a multiple-mode interference (MMI) cavity.

1 23. A method of forming a waveguide photodetector, comprising:
2 forming semiconductor islands from a semiconductor layer overlying an
3 insulating layer of a substrate;
4 forming insulating regions between the semiconductor islands;
5 forming atop the semiconductor layer a first waveguide core, a multiple
6 mode interference (MMI) cavity core adjacent the first waveguide core, and an array
7 of second waveguide cores atop the islands and adjacent the MMI cavity;

8 forming for each second waveguide core a PIN detector having an intrinsic
9 region adjacent a surface of the second waveguide; and
10 forming a cladding over the first waveguide core, the MMI cavity core and
11 the array of second waveguide cores.

1 24. The method of claim 23, including forming the first waveguide core, the
2 MMI core and the array of second waveguide cores by processing a layer of one of
3 Si, Ge, Ge on Si, $\text{Ge}_x\text{Si}_{1-x}$, SiO_xN_y and Si_3N_4 formed atop the semiconductor layer.

1 25. The method of claim 23, wherein portions of the islands are doped to form
2 n+ and p+ electrodes that surround the intrinsic region.

1 26. A method of processing an electrical signal, comprising:
2 converting the electrical signal to a guided wave optical signal representative
3 of the electrical signal;
4 dispersing the guided wave optical signal into multiple (N) guided wave
5 modes;
6 forming N interference nodes from the N guided wave modes;
7 coupling the light from the N interference nodes into corresponding N
8 detector waveguides; and
9 coupling the light traveling in each of the N waveguides to a corresponding
10 intrinsic region in each of N PIN detectors and generating an output photocurrent
11 electrical signal representative of the guided wave optical signal.

1 27. The method of claim 26, wherein the electrical signal is a time-division
2 multiplexed signal, and further including:
3 demultiplexing the output photocurrent electrical signal to form
4 demultiplexed electrical signals.

1 28. The method of claim 27, including guiding the guided wave optical signal
2 over a single-mode waveguide.

1 29. The method of claim 28, wherein the single-mode waveguide comprises an
2 optical fiber.

1 30. An optoelectronic system, comprising:
2 a waveguide photodetector including:
3 a multiple mode interference (MMI) cavity having an input end and
4 an output end, an input waveguide optically coupled to the MMI
5 cavity at the input end, an array of detector waveguides optically
6 coupled to the MMI cavity at the output end and each optically
7 coupled to an intrinsic region surrounded by first and second
8 electrodes so as to detect photon-generated carriers formed in the
9 intrinsic region and output a photocurrent;
10 an input device optically coupled to the input waveguide that generates an
11 optical signal and inputs the optical signal into the input waveguide; and
12 an output device to receive the photocurrent.

1 31. The optoelectronic system of claim 30, wherein the input device includes
2 one of a laser diode and vertical cavity surface emitting laser.

1 32. The optoelectronic system of claim 31, wherein and the output device
2 includes a transimpedance amplifier.

1 33. An optoelectronic clocking system, comprising:
2 an input device that generates an optical signal;
3 an optical edge tree comprising a main waveguide optically coupled to the
4 input device, and a plurality of equal-length waveguide branches extending from the
5 main waveguide;
6 a waveguide photodetector coupled to each waveguide branch, each
7 waveguide photodetector including:

